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14. ABSTRACT
This TOP describes the different methodologies and associated procedures that can be followed to evaluate the visual and aural detectability and characteristics of a vehicle (wheeled and tracked) to determine the limits of detectability. Methodologies such as Magnitude Estimation (ME), Method of Limits (MOL) and Method of Constant Stimuli (MCS) will be investigated and procedures described for implementing each. The procedures are limited to the assessment of vehicles detected by observers with the human eye, and can be applied to either unaided or aided by binoculars.

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US ARMY DEVELOPMENTAL TEST COMMAND
TEST OPERATIONS PROCEDURE

*Test Operations Procedure 02-2-615A — 24 February 2011
DTIC AD No.

SECURITY FROM DETECTION (VEHICLES)

*This TOP supersedes TOP 02-2-615, 24 September 1993.

1. SCOPE.

This TOP describes the different methodologies and associated procedures that can be followed to evaluate the visual and aural detectability and characteristics of a vehicle (wheeled and tracked) to determine the limits of detectability. Methodologies such as Magnitude Estimation (ME), Method of Limits (MOL) and Method of Constant Stimuli (MCS) will be investigated and procedures described for implementing each. The procedures are limited to the assessment of vehicles detected by observers with the human eye, and can be applied to either unaided or aided by binoculars. Infrared (IR) testing is described in TOP 02-2-812[1]**. Instrumental measurements of sound are described TOP 01-2-608[2] and Military Standard (MIL-STD)-1474D[3]. Procedures for conducting Detection, Recognition and Identification (DRI) testing with thermal imagers are described in International Test Operations Procedure (ITOP) 06-3-041[4]. General measurements for signature testing are provided in the Signature Measurement Guidebook, Draft[5].

1.1 Purpose.

The purpose of this document is to provide methodologies and procedures for conducting security from detection tests for ground vehicles. For the purpose of brevity, the term or reference to vehicles, wheeled or tracked will be referred to as System Under Test (SUT).

1.2 Applicability.

a. The information provided in this TOP is intended to aid personnel in designing tests for security from detection and the development of test plans. It is designed to provide a 'quick look' at the detectability of systems in an efficient manner, employing minimal resources to manage costs effectively. It is not intended to cover all possible test scenarios. It will provide methodologies that can be used to quickly assess detectability limits for a SUT.

b. An ME test would be used for a rapid comparison of items/SUT(s) to determine a qualitative assessment of the SUT when resources/manpower and time are not available to acquire the required data. Typically, this type of test would be used when comparing a baseline system (for example, "system A") to an improved or next generation system (for example, system "A1") or many similar systems to determine the best performer. Again, this type of methodology is intended to be a qualitative assessment between two or more SUTs and is generally conducted to determine a quick look at the items (SUT(s)) under test.

c. MOL and MCS tests would be used to provide a more quantitative assessment and can be used to generate a Probability of Detection (PD) curve for the environmental conditions tested in. These methodologies can be used to test several different SUTs or compare a baseline to an improved (A1) system.

**Superscript numbers correspond to Appendix F, References.

2. FACILITIES AND INSTRUMENTATION.

2.1 Facilities.

Item	Requirement
Viewing Area (Test Range)	Unobstructed relatively level distance of at least 2800 meters with backgrounds as required addressing criteria/specifications.
Test Courses	For moving vehicle tests, paved and gravel with level and hilly terrain.

2.2 Instrumentation.

Devices for Measuring	Permissible Measurement Uncertainty
Video/Photographic Equipment	Not applicable
Near-IR Video/Photographic Adapter	Not applicable
Personal Pocket Computer (PPC)	Not applicable
Tachometer (engine speed (if applicable))	$\pm$ 2 percent full scale (0 to 5000 revolutions per minute (rpm))
Photometer (luminance)	$\pm$ 4 percent of full scale (10^{-4} to 10^{4} nits)[6]
Photometer (ambient illumination)	$\pm$ 4 percent of full scale (10^{-4} to 1.3×10^{5} lux)[6]
Anemometer (wind speed)	$\pm$ 0.08 m/s (0 to 9 m/s)
Anemometer/wind vane (wind direction)	$\pm$ 3 percent
Thermometer (ambient temperature)	$\pm$ 2 °C (-35 to 50 °C)
Hygrometer (relative humidity ((RH))	$\pm$ 3 percent (5 to 95 percent RH)

Illuminance/luminance measurements can be done in different ways using different instrumentation and software. Measurements may only need to be done when the data are required by the systems criteria, Program Manager (PM), evaluators, or analysts. The instrumentation and different procedures are discussed in Appendix A.

3. REQUIRED TEST CONDITIONS.

3.1 General.

Unaided or aided detection with eyes only depends upon the level of visibility through the atmosphere. The main interest in conducting a test is to determine the extent that a SUT, either by its appearance and/or operation, provides a means of being visually detected.

a. Visibility conditions shall be clear, even in darkness; visibility shall be at least 5000 meters.

b. Observations shall be made over terrains free from visual obstructions.

c. A detailed matrix sheet should be developed prior to testing that will provide guidance as to the desired range, SUT orientations, operating condition, and lane position (left or right) for each run number. This should be done for any of the tests described in paragraph 4.

3.2 SUT (Ground Vehicles).

a. The SUT should be clean and have a fully operational power train and if possible have appropriate Basic Issue Items (BII) and On-Vehicle Equipment (OVE). This would also include any camouflage or other equipment that a military unit might outfit a SUT with. The SUT should be at combat weight.

b. If the SUT is an upgraded version of a previous SUT (baseline) it should be compared directly to that baseline. This is preferable because atmospheric conditions affect detectability and testing them concurrently ensures comparable data. The baseline SUT shall have known characteristics or if a baseline is not available, current test data can be compared to existing or previous data.

c. The highest grade of fuel shall be used for all tests, unless otherwise specified. Fuel type affects the noise and exhaust characteristics of diesel engines. Fuel grades used during the test shall be those specified for engine operation under the particular climatic condition.

d. Vehicle interior and exterior illuminating systems must be operational.

3.3 Personnel.

a. Personnel used as observers must have their vision tested and should be evaluated for near and far visual acuity, depth perception, and color vision anomaly, for both eyes and each eye individually. It is desirable to have a range of acuity levels as would be present in the military population. However, because of the well known effects of age on vision, in a test where observers will use their unaided eyes, ages should be between 18 and 50. Or, if the maximum age for the Military Occupational Specialty (MOS) can be determined, that age should be the cutoff. These tests can be conducted using a Titmus® Vision Tester (TVT) or other

similar device. Color vision can be assessed using the seven Ishihara Pseudo-Isochromatic plates usually contained in the TVT.

b. Personnel chosen as observers for aural detectability tests must also have hearing ability consistent with the normal threshold of audibility as defined in American National Standards Institute (ANSI) S3.6[7].

c. A minimum of 10 observers shall be used for each test to ensure that the sample size is large enough for analysis performed on the results to be statistically meaningful. If possible, 20 observers should be used.

d. The observers should have a clear and concise understanding of the objective and purpose of the test. In many instances, an observer controller is necessary to assist the observers and answer questions during the test. A script, similar to the one presented in Appendix B, Figure B-1 should be used to instruct the observers on the task required. This should be read to all of the observers, the goal of this procedure is to ensure everyone achieves the same level of understanding of the task rather than all receive an identical set of instructions. The observers should be encouraged to ask questions regarding the procedures/instructions to ensure that they understand the task.

4. TEST PROCEDURES.

4.1 General.

The following methodologies and procedures can be tailored and applied to any type of Security from Detection test. Various other Security From Detection tests that could be required are outlined in Appendix C.

a. The following shall be observed for visibility (unaided eyes) test:

(1) Photography shall be used whenever possible to document the results. During very low ambient light levels, use an image intensifier attached to the front of a camera or video camera.

(2) The size of the visual field should be clearly defined to the observers. The observers should be given time to look at the area where the SUT will be deployed before there are targets in the scene.

(3) Observers should be allowed sufficient time to scan the viewing area (2 to 3 minutes) for each target presentation.

(4) Control of communication between observers to prevent cueing must be maintained at all times. An observer controller should be present throughout testing.

(5) Dark adaptation of the observers' vision should be conducted in a totally dark area for at least 20 to 30 minutes for tests conducted in the dark.

(6) No data shall be taken under a specific engine operating (steady-state) condition until torque, speed and temperatures have been maintained substantially constant for at least 1 minute.

(7) The orientation of the SUT with respect to the observers for tests which require a stationary position should be as specified in the SUT criteria or test plan. At a minimum, the following aspects shall be tested: front view, front quartering view (45 °), and a side view. Observers shall be positioned so that the SUT(s) are not backlit (i.e., the sun shall be at the observers' backs). This presents a worst case condition, in that the SUT will be the most difficult to detect.

(8) A matrix shall be developed with the SUT orientations, desired range, lane reference (left or right), and SUT identified by a trial number/run number. If testing multiple SUTs, care should be taken to ensure the trials/runs of each SUT are equal for all parameters tested.

b. The following methodology tests shall be conducted along known lines of sight (LOS). This can allow a large number of iterations to be run as it eliminates the need for search since the SUT(s) are along a known LOS.

4.2 Test Methodologies.

4.2.1 Magnitude Estimation (ME).

a. In a ME experiment, subjects are presented with a standard stimulus (a modulus) and are told that the stimulus has a magnitude of a certain value, like 20. The subjects are then presented with a series of stimuli that vary in intensity and are asked to assign each of the stimuli a number relative to the standard stimulus. For example, if the current stimulus is twice as intense as the standard stimulus it should be called 40 or if it is half as intense, it should be called 10 (Snodgrass, Levy-Berger & Haydon, 1985[8]). Scaling is in no way about absolute accuracy of judgments; scaling is about the relative relationships between judgments of stimuli of different intensities (Information Processing in Human Perceptual Motor Performance[9]).

b. This methodology can be applied to field testing or in layman's terms, two or more SUTs can be compared to each other, in a relative sense, using a scaling factor when tested in the same environment (background/foreground, orientation, sun angle, etc.). This type of methodology can be used for a rapid comparison of SUT(s) to determine a qualitative assessment of the SUT when resources/manpower and time are not available to acquire the data required. Typically, this type of test would be used when comparing a baseline system (A) to an improved or next generation system (A1) or many similar systems to determine the best performer.

c. Method.

(1) Testing shall be conducted in the environmental conditions and background (grass, trees, bushes, desert, snow) desired. The area selected shall be large enough so the background is consistent behind adjacently placed SUT(s).

(2) The SUTs shall be placed at a range where they can be seen and identified; both will be at the same range and orientation with respect to the observers' position.

(3) Observers must be instructed to keep comments regarding observations to themselves and not talk during trials.

(4) Observers are positioned at a distance from the SUT(s) as determined by the test coordinator, turned away from the SUT(s) or seated in booths so they cannot see the SUT(s). When told to start to observe they shall face the LOS and view the SUT(s) and note differences in the SUT(s). Differences noted will depend on the objective of the test and the desired data, for example, if the objective/purpose of the test is to determine how well the SUT blends with the background compared to the baseline system, a scoring/scaling system may be 10 for perfect blend and 0 for terrible blend.

(5) Trials shall be repeated with different orientations, and under different lighting conditions until all SUT configurations have been tested. Each trial shall be repeated three times if time permits.

(6) Observer data can be recorded manually on paper or digitally on a PPC or Personal Data Assistant (PDA). The observer score sheets would generally not be numbered when presented to the observers and would be designed so that when the observer marked the score sheet it could be scaled to determine a numerical value. A sample of a paper sheet is shown in Appendix D, Figure D-1 and of a display of a PPC score sheet is shown in Appendix D, Figures D-2 and D-3.

4.2.2 Method of Limits (MOL).

a. In ascending method of limits, some property of the stimulus starts out at a level so low that the stimulus could not be detected, and then this level is gradually increased until the participant reports that they are aware of it. For example, if the experiment is testing the minimum amplitude of sound that can be detected, the sound begins too quietly to be perceived, and is made gradually louder. In the descending method of limits, this is reversed. In each case, the threshold is considered to be the level of the stimulus property at which the stimuli is just detected (Psychophysics: The Fundamentals[10]).

b. In experiments, the ascending and descending methods are used alternately and the thresholds are averaged. A possible disadvantage of these methods is that the subject may become accustomed to reporting that they perceive a stimulus and may continue reporting the same way even beyond the threshold (the error of habituation). Conversely, the subject may also

anticipate that the stimulus is about to become detectable or undetectable and may make a premature judgment (the error of expectation) (Psychophysics: The Fundamentals).

c. To avoid these potential errors, a stair case procedure can be applied by alternating procedures; ascending and then descending several times and then average the results of each to get the detection range. This would be done by starting at a range along a known LOS where none of the observers can see the SUT(s) and decrease the range until all observers can easily see the SUT(s) and then reverse that cycle. This shall be done several times until an average limit of detection is determined. Sham runs shall be included in the run matrix. Sham runs are runs without targets in the LOS. This is done to keep observers honest and avoid the possibility of guessing.

d. Method.

(1) This test can be designed to be conducted either with a single SUT or with two systems. If two systems are used, care must be taken to track the orientation and reference or placement of each SUT in regard to which system is on the left or right with respect to the observers.

(2) Testing shall be conducted in the environmental conditions and background (grass, trees, bushes, desert, snow) desired. The area selected shall be large enough so the background is consistent behind the SUT(s).

(3) The desired number of lanes shall be surveyed with appropriate range increments between the ranges to determine the limit of detectability for the SUT(s). The ranges chosen should allow the SUT(s) to be easily detected and then not detected at all. This shall be done along a straight line toward the desired background.

(4) Observers shall be instructed to keep comments regarding observations to themselves and not talk during trials.

(5) There are two different ways the test may be performed depending on the criteria stated or requirements from PM, evaluators or analysts. The scenarios would be to keep the observers in the same place and move the SUT(s) through the different range increments or have the SUT(s) in the same place and have the observers move in or out through the range increments. Each scenario is described below:

(a) When the background is relatively uniform, the SUT(s) shall be moved either closer or farther away from the observers. Observers shall be positioned at a distance from the SUT(s) as determined by the test coordinator, turned away from the SUT(s) or seated in booths so they cannot see the SUT(s). The SUT(s) shall move into position for trial number one in accordance with the matrix developed. When told to start the trial, observers shall face the LOS and view the SUT(s). Observers will note on the score sheets or PPC whether they can detect the SUT(s) or not. When the observers have finished viewing the SUT(s) they will turn and face away from the SUT(s) or sit down if using observer booths and continue to fill out their score sheets. The test controller or observer controller will let the down-range crew know that the trial

is over and have them move into position for the next trial in accordance with the matrix, and the procedure is repeated.

(b) When the SUT(s) are required to stay in place to maintain a consistent background, for example along the edge of a tree line, the observers will move either closer or further away from the SUT(s). When this is the case observer scores can be done in two different ways:

1 Observer scores can be recorded by the observer controller; this is accomplished with the observers facing away from the SUT(s) prior to the trial starting. When the SUT(s) are in position the observer controller has them turn around to observe. The observer controller will have them put one arm/hand behind their back. The observer(s) will let the observer controller know if they can see the SUT(s), without talking, by giving thumbs up if they can detect the SUT(s) or thumbs down if they cannot. The observer controller shall note the observers' score on a score sheet or the observers may have a score sheet and will mark their score down for that trial number.

2 When the PPCs are used to score data, the observer controller must ensure that each observer knows the trial number and ensure that the number matches the trial number displayed on the PPC. The PPC trial number will increment automatically when data are entered and stored. The observers shall annotate a “YES” on the PPC for each trial if they are able to detect the SUT or “NO” if they are not able to detect. Additional comments can be entered into a small booklet if desired. The booklet will be given to the observers and they will be instructed to ensure the trial number is placed before any comment. When the observers finish looking for the SUT(s) they will turn and face the observer controller and if required finish scoring the trial. The test controller or observer controller will let the down-range crew know that the trial is over and have them move the SUT(s) into position for the next trial in accordance with the matrix, and the procedure is repeated.

(6) Trials can be repeated with different orientations, and under different lighting conditions until the SUT configurations required have been tested. Each trial shall be repeated three times if time permits.

4.2.3 Method of Constant Stimuli (MCS).

a. Instead of being presented in ascending or descending order, in the MCS the levels of a certain property of the stimulus are not related from one trial to the next, but presented randomly. This prevents the observers from being able to predict the level of the next stimulus, and therefore reduces errors of habituation and expectation. The observers again report whether they are able to detect the stimulus. The Personal Data Assistant allows for full sampling of parameters of a physical stimulus and the responses of a person who has to decide about a certain aspect of that stimulus. This type of test methodology can result in a lot of trials when several conditions are interleaved (range, orientation, different SUTs, etc.).

b. This method varies the presentation of the SUT(s) along a given LOS randomly so the observers cannot anticipate or expect the SUT(s) from one trial to the next.

c. Sham runs shall be included in the run matrix. Sham runs are runs without targets in the LOS. This is done to keep observers honest and avoid the possibility of guessing.

d. Method.

(1) This test can be designed to be conducted either with a single SUT or with multiple systems. If more than one system is used, care must be taken to track of the orientation and reference or placement of each SUT in regard to which system is on the left or right with respect to the observers.

(2) Testing shall be conducted in the environmental conditions and background (grass, trees, bushes, desert, snow) desired. The area selected shall be large enough so the background is consistent behind the SUT(s).

(3) The desired number of lanes shall be surveyed with appropriate range increments between the ranges to determine the limit of detectability for the SUT(s). The ranges chosen should allow the SUT(s) to be easily detected and then not detected at all. This shall be done along a straight line toward the desired background.

(4) Observers shall be instructed to keep comments regarding observations to themselves and not talk during trials. For this type of test, it is more advantages to keep the observers in a fixed location and move the targets in and out of the field of view (FOV) as necessary.

(5) Observers shall be positioned at a distance from the SUT(s) as determined by the test coordinator, turned away from the SUT(s) or seated in booths so they cannot see the SUT(s) or the field of regard (FOR). The SUT(s) will move into position for a given run number when the observers are seated and cannot see the FOR. When told to start to observe, they shall stand and face the LOS and view the SUT(s). Observers will note on the score sheets or PPC whether they can detect the SUT(s) or not and note which SUT, if two or more are tested, and note the orientation. If observer booths are used, each observer will sit down when done observing and continue to fill out their score sheets.

(6) The test controller or observer controller will let the down-range crew know that the trial is over and have them move the SUT(s) into position for the next trial in accordance with the matrix and the procedure is repeated.

(7) Trials can be repeated with different orientations, and under different lighting conditions until the SUT configurations required have been tested. Each trial shall be repeated three times if time permits.

4.3 <u>Illumination Visibility</u>.

Determine the methodology (ME, MOL or MCS) that will best address the objective of the test and criteria. The SUT will be viewed from various distances, elevations, and at various radial positions in darkness. Care must be taken to ensure that the observers' eyes are fully adapted to darkness.

4.3.1 Exterior Illumination.

Method. Perform the following in darkness (blackout) with the SUT(s) in stationary positions.

a. Operate the SUT(s) various exterior lights, one at a time from 0 ° azimuth (frontal view) to 360 ° in 45 ° increments. Determine the maximum distances that the following (as applicable) are visible to the observers at eye level:

(1) Service headlights.

(2) Service taillight(s).

(3) Service stoplight(s).

(4) Blackout marker stoplight.

(5) Blackout driving light(s).

b. Determine the maximum distances that the lights in step 4.3.1a (as applicable) are visible to observers at a height of 4.5 meters.

c. Repeat steps 4.3.1a and 4.3.1b until a minimum of three runs/trials have been made for each light and condition.

4.3.2 Interior Illumination.

The extent to which the interior lights of a combat vehicle can betray its position will be observed at various distances in darkness. Care must be taken to ensure that the observers' eyes are fully adapted to darkness. When light is detected, the distance of observation will be increased, and the positions at which the light is no longer observed will be recorded. When the elevation of the vehicle is too high for direct observation of the light, the vehicle may be backed up a slope to get the desired angle (about 17 degrees). Care shall be taken to ensure that the periscopes and sights are unobscured from the inside. Particular attention should be given to light leakage around the mantlet openings provided for primary and secondary armament, and around hatches.

Method. Perform the following in darkness (blackout) for the SUT(s) in stationary positions with the SUT(s) in the "buttoned-up" configuration and the combat lighting and instrument lighting illuminated. The SUT(s) should be tested in the orientations described in paragraph 4.3.1a.

a. Determine the maximum distances and radial directions that the vehicle interior lighting and various instrument lights (as applicable) are visible to the observers at eye level.

b. Determine the maximum distances and radial directions that the interior illumination and instrument lights are visible to observers at a height of 4.5 meters.

Note: Direct observation from a 4.5-meter height can be simulated by backing the vehicle up a slope to an approximate angle of 17 °.

c. Repeat steps 4.3.2a and 4.3.2b until a minimum of three runs/trials have been made for each condition.

4.4 Jury-Type Noise Tests.

a. To utilize the human ear as a qualitative noise measuring device, jury-type tests are conducted for comparing two SUTs, typically a baseline vehicle (A) with an improved vehicle (A1), however, different SUTs can be used. These tests consist of independent observations made by a minimum of 10 "jury" members. Each observer must have hearing ability consistent with that defined in paragraph 3.2b. The assumption is made in tests of this nature that comparisons based upon individual vehicles will be valid if several vehicles are operating in convoy.

b. Tests are generally conducted on both hard-surface roads and over cross-country terrain with vehicles operating in circles and/or figure-eight. This provides opportunities for observing directional effects, particularly in the case of the engine, which can be considerably masked from some directions.

c. It is preferable to conduct these tests at a distance from which both SUTs can be heard regardless of instantaneous orientation with respect to the observers. A low gear ratio should be used so that engine noise will be at or near maximum. When suspension system or track noises are the principal concern, however, it may be desirable to operate in the gear producing the lowest level of engine and transmission noise.

d. The tests shall not be conducted when the wind velocity at the test site is greater than 4.5 m/s.

e. Tests should be conducted at dawn in order to minimize extraneous noise and to provide a standard of detection susceptibility using the worst-case condition.

f. Perform the following in moderate ambient temperatures with low relative humidity for the SUT(s):

(1) Operate the SUT(s), simultaneously, but at opposite ends, over a test course of circular or figure-eight configurations at least 1.5 km in length consisting of:

(a) Hard surfaced road.

(b) Cross-country terrain.

Note: A low gear rate shall be used so that engine noise will be at or near maximum levels.

(2) An observer controller with the observers will record the scores of the observers. The observers will be blindfolded so they cannot see the SUT(s), the observer controller will let the observers know which SUT is operating, i.e., identified as SUT 1 or SUT 2. With a "jury" of observers positioned 60 meters from the center of the test course, each SUT will be rated with respect to each other by the noise which each produces using the following rating scale:

The SUT 1 is:

(a) Louder than SUT 2.

(b) Somewhat louder than SUT 2.

(c) The same as SUT 2.

(d) Somewhat quieter than SUT 2.

(e) Quieter than SUT 2.

(3) The observers shall hold up one finger, two fingers, three fingers, etc., to indicate their rating of the SUT as described above.

(4) Repeat steps 4.4f(1) and 4.4f(2) until a minimum of three runs have been made by each SUT over the test course.

(5) Repeat steps 4.4f(1) through 4.4f(3) at increased observation distances, in increments of 60 meters, until the threshold of hearing is approached.

(6) Repeat steps 4.4f(1) through 4.4f(4) for the following conditions as applicable to the systems specification/criteria:

(a) Moderate ambient temperatures and high relative humidity.

(b) High ambient temperatures and low relative humidity.

(c) High ambient temperatures and high relative humidity.

(d) Low ambient temperatures and low relative humidity.

(e) Low ambient temperatures and high relative humidity.

(f) Low ambient temperatures with surroundings under heavy snow cover.

5. DATA REQUIRED

Demographic data shall be collected on all observers; a sample of a blank Demographic Questionnaire is presented in Appendix B, Figure B-2.

5.1 ME, MOL and MCS Tests.

a. Documentation will be provided detailing all aspects of testing including the following:

(1) Observation number.

(2) Visual acuity of each observer (from vision test).

(3) Observer identity (observer identity is kept confidential and separate from individual observer results).

(4) SUT(s) identity, model number and serial number.

(5) SUT operator identity.

(6) Course layout description.

(7) Observation distance from the center of the SUT(s) in meters.

(8) Color photographs of test setup and FOV with SUT(s) against background terrain.

(9) Ambient illumination (if required).

(10) Total number of possible detections.

(11) Total number of correct detections.

(12) Meteorological data.

(13) Observer demographic data.

(14) Observer comments about detection of SUT(s).

b. Sample score sheets that can be used (paper and PPC) for ME, MOL and MCS tests are shown in Appendix D.

5.2 Illumination Visibility.

The following data will be recorded for Illumination tests:

a. Observation number.

b. Visual acuity of each observer (from vision test).

c. Observer identity.

d. SUT(s) identity, model number and serial number.

e. SUT operator identity.

f. Distance at which the exterior or interior light is visible, in meters.

g. Observer's radial direction with respect to the vehicle, in degrees.

h. Light identity external (service headlight, blackout driving light, etc.); interior (dome light leak, instrument light, etc.).

i. Light location, external (front, rear, front left, etc.); interior (hatch, periscope, sight, etc.).

j. Type of lighting in use (white lighting, combat lighting).

k. Distance at which the exterior/interior light is visible at a height of 4.5 meters, in meters.

l. Ambient illumination.

m. Total number of possible detections.

n. Total number of correct detections.

o. Observer demographic data.

p. Observer comments about detection of SUT(s).

5.3 Jury-Type Noise Tests.

The following data will be recorded for Jury Noise tests:

a. Observation number.

b. Audio test results of each observer.

c. Observer identity.

d. SUT(s) identity, model number and serial number.

e. SUT operator identity.

f. Driver identity.

g. Course layout description.

h. Observation distance from the center of the vehicle, in meters.

i. Test vehicle noise relative to baseline vehicle noise.

j. Directional effects due to the orientation of the test vehicle with respect to observer.

k. Wind speed, direction, temperature and humidity.

l. Presence of snow cover, as applicable.

m. Observer demographic data.

n. Observer comments about detection of SUT(s) (if applicable).

6. DATA PRESENTATION

a. Data of successful detections, total number of possible detections and percent correct can be presented in tabular or graphical form. It can also be broken down into the different parameters i.e., by percent correct detections by orientation versus range, or lighting condition versus range, etc., depending on how many different parameters may be dictated as part of the test. The way in which the data is presented will depend on the requirements or criteria of the test.

b. A sample of tabular data and graphical data for MOL or MCS tests that could be presented is shown in Table 1 and Figure 1, respectively.

c. Demographic data (visual and audio) will be presented in tabular form. A sample of demographic data for a visual test is shown in Table 2.

TABLE 1. SAMPLE DETECTION VERSUS RANGE A SINGLE SUT

Tabular Example of Detection Versus Range			
Range, m	**Correct Detections Possible**	**Correct Detections**	**Percent Correct Detections**
100	48	48	100
200	48	48	100
300	48	48	100
400	48	48	100
500	48	48	100
600	48	47	98
700	48	46	96
800	48	41	85
900	48	40	83
1000	48	36	75
1100	24	15	63

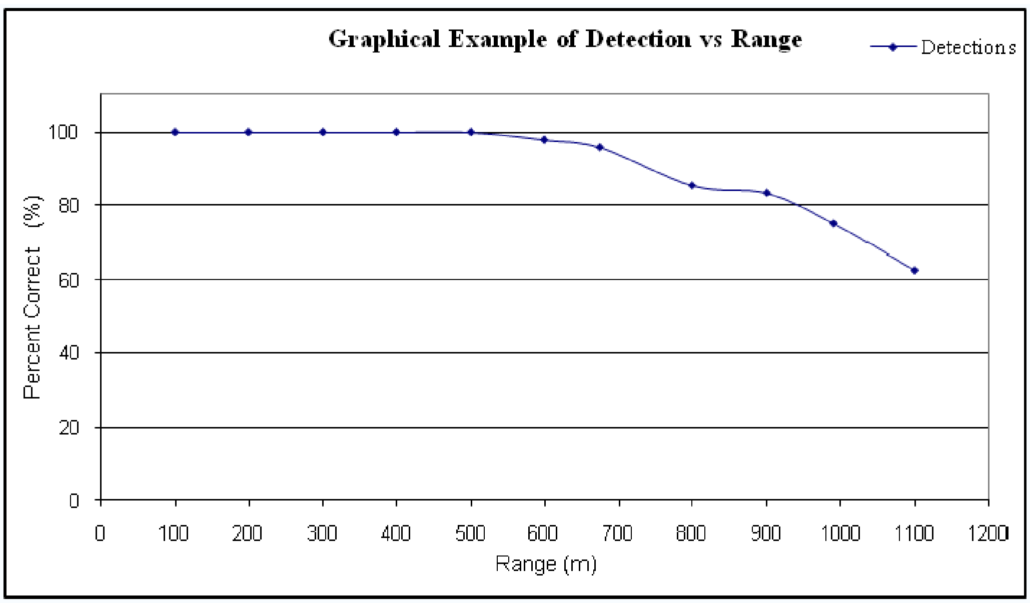

Figure 1. Graphical example of detection results versus range.

TABLE 2. SAMPLE DEMOGRAPHIC, FAR VISUAL ACUITY AND COLOR VISION DATA FOR TEST PARTICIPANTS

Observer No.	Age	Rank	MOS	Time in Service	Time in MOS	Training in Target Detection	FAR Visual Acuity [a]			Glasses[b]	Color[c]
							Both	L	R		
1	46	CIV	11B	26 yr	26 yr	22 yr	50	100	20	N	N
2	41	CIV	USMC	7.5 yr	7.5 yr	7.5 yr	15	17	22	N	N
4	34	CIV	USMC	6 yr	6 yr	4 yr	15	17	15	N	F
5	48	SSG	11B30	16 yr	14 yr	6 yr	18	20	22	N	N

[a] The visual acuity data presented is the denominator of the Snellen fraction, i.e., 20/13 with 13 recorded above. Normal vision is 20/20, therefore, less than 20 indicates better than normal vision while values above 20 indicate below normal visual acuity.

[b] "N" Indicates whether the observer wore glasses during the vision assessment and testing.

[c] Color vision: "N," indicates normal color vision, "M," a mild color deficiency and an "F," failure of this test.

CIV = Civilian, retired soldier.
SSG = Staff Sergeant.
USMC = United States Marine Corps.

APPENDIX A. ILLUMINATION MEASUREMENTS

When luminance or illumination measurements are required there are many different types of photometers that can perform the measurements. Care must be taken to choose the appropriate equipment depending on the sensitivity of the measurement required. For measurements made during the day a hand-held photometer, sometimes referred to as a “light meter” may be adequate. If measurements are required in low to very low light conditions (twilight, moonlight or moonless night), measurements need to be made with an instrument with the sensitivity to go down to 10^{-4} lux (lm/m^2)[6]. In these cases, a hand-held photometer may not have the sensitivity required and a photometer similar to a Photo Research® Pritchard PR®-880 Photometer/Colorimeter*** or equivalent that has the sensitivity to go down to 10^{-4} will be required.

Method. The illumination of the sky shall be measured using either a hand-held photometer that will read and display illumination (daylight or high light levels) directly or a photometer looking at a diffuse reflectance standard of nearly 100 percent. When the photometer is viewing a reflectance standard the output will be luminance and will need to be converted to illuminance. Program the photometer to the units (U.S. Customary or International System of Units (SI)) desired. When working in the northern hemisphere the photometer should be positioned on the North side of the reflectance standard so the instrument does not cast a shadow on the plate. Remove the protective cover from the reflectance standard plaque and place the plaque in the plane that the illuminance measurement is desired. Orient the optical head of the photometer at an angle of no greater than 45 ° from a line perpendicular to the surface of the plaque. Select a value of measuring field aperture which is smaller than the image of the plaque in the viewfinder. Measure the luminance of the plaque (Instruction Manual for The Pritchard Model 1980B Spectroradiometer[11]).

If the photometer can be configured to record data, it should be recorded at a frequency that will not exceed the storage media for the test time period required. The data typically would be recorded as a text file with date and time encoding. A typical setup of a photometer, aimed at a 10- by 10-inch reflectance standard (white plate) and connected to a data logger, is shown in Figure A-1. The photometer is connected to a data logger that uses a flashcard to store data.

***This does not in any way constitute an endorsement of this product.

APPENDIX A. ILLUMINATION MEASUREMENTS

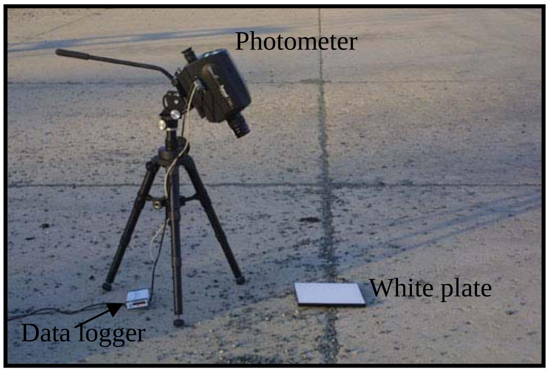

Figure A-1. Photometer and reflectance standard white plate for illumination measurements of moonlight.

Luminance measurements will need to be converted to illuminance, U.S. Customary (English) units (foot-lamberts) or SI (Nit (Cd/M^2)). The formula for converting luminance to illuminance for English units and SI units are shown below:

U.S. Customary (English) units:

$$\text{Illumination (in foot-candles)} = \frac{\text{CF x Luminance (in foot-lamberts)}}{R}$$

In SI:

$$\text{Illumination (in Lux)} = \frac{\text{CF x } \pi \text{ x Luminance (in Nits)}}{R}$$

Where CF = Correction Factor for the Photometer (if required).
π = the mathematical constant pi (3.1415...).
And R = .99 (nominal reflectance of spectralon standard).

Lux = Lumens per meter squared.

A correction factor may come from an installation’s local Test Measurement Diagnostic Equipment (TMDE) facility. If the instrument is calibrated at the factory a correction factor should not be required as the instruments are normally calibrated and adjusted to read accurately. The correction factors from a TMDE facility account for changes in measurement accuracy since the last time adjustments were made to correct the instrument measurement.

APPENDIX B. REQUIRED OBSERVER INFORMATION

OBSERVER INSTRUCTIONS

There are three parts to the testing you will be participating in. At a convenient time, I am going to give you an eye test, the same kind of thing they do when you get your driver's license. I will be checking your visual acuity, or how good your vision is, evaluating your color vision, and depth perception. There will also be a training session, before any data are collected on this test, in which I show you what you will be doing during this test and you will get a chance to practice the procedures. Finally, you will actually do the test!

I am going to assign you an observer number. This number will ensure that you are anonymous. None of your supervisors will be given a report of your performance, and your name will never be connected with your data. Someone somewhere may know that you worked on this project, but no one will know how well you did!

For the purposes of this test YOU represent the Army. It is important that you do the best job you can - and I want to help you do that. If there is anything that you do not understand, please ask questions!

THE PURPOSE of this test is to collect data on the detectability of the SUT. In these tests we will use the definitions from the Department of Defense (DoD) Joint Publication 1-02[12] for ground operations:

DETECTION. In tactical operations, the perception of an object of possible military interest but unconfirmed by recognition.

RECOGNITION in this experiment is as defined in DoD Joint Publication 1-02, "in ground combat operations, the determination that an object is similar within a category of something already known; e.g., a tank, truck or a man."

We are going to position the SUTs at different ranges in roughly a straight line from your position. They will be oriented in different positions facing you. There may be one or two targets, and they may be stationary or moving. They will always be in full view, we are not going to conceal them in any way. There will also be times when there is no target in the scene.

You will be conducting the test with unaided eyes. When I give you the start signal you will stand/turn around and look down range. If you can detect the target, please note that in the booklet or on the PPC, and then describe the target in the second column, i.e., one vehicle, right side, moving, etc., and note, if possible, what made the SUT detectable.

Figure B-1. Sample of an Observer Script.

APPENDIX B. REQUIRED OBSERVER INFORMATION

During this training session I will answer any questions that you have concerning the procedure or the images you are seeing. Once the test starts, you are on your own! Ask now or forever hold your peace!

It is very important that you understand the purpose and procedure of this test. Are there any questions?

One last thing before we begin--Have you ever had to use a piece of equipment, and asked yourself who developed this piece of junk?! Well, at some point in the acquisition process all equipment is tested, so that piece of equipment may be the way it is because a soldier thought that nothing he/she said or did made a difference. That soldier was WRONG--here is your chance. For the purpose of this test, you represent the Army. Soldiers coming behind you may use these SUTs. Lives may depend on them--maybe yours or someone you know.

Figure B-1. (Cont).

Demographic Questionnaire

Observer No. ______

Name: ____ Age: __________

Rank: ____________ MOS: _________________ Time in MOS: (yr/mo)___________

Time in Service: (yr/mo) ________________

Previous MOS: ___________________________ Time: (yr/mo) ___________________

Normal Duty Position: ____

How much training have you had in target acquisition? (yr/mo) _____________________

How much time have you spent in field units? (yr/mo) ____________________________

How much time have you spent, either in the field or during training, acquiring vehicular targets? (yr/mo) ____

Have you had any other experience related to this task? Please list and explain.

Figure B-2. Demographic Questionnaire.

APPENIX C. OTHER SECURITY DETECTION TYPE TESTS

C.1 General. The detection cues and tests described below can also contribute to the detectability of a SUT. Generally, many of the Required Test conditions in paragraph 3 apply to most of the different tests described below. Any of the methods described in Test Procedures, paragraph 4, Data Required, paragraph 5.1 and Presentation of Data, paragraph 6 will apply; the type of methodology chosen to conduct the testing will depend upon the scope, objective, and the criteria required for the test.

C.2 Size, Shape, Silhouette. Visibility of a vehicle usually should be tested against various backgrounds. A comparison of views from various angles and distances of two similar SUTs is desirable. In the case of smaller SUTs, comparisons are made when the SUTs are partially obscured by brush or tall grass. The vehicles are viewed under normal conditions and care should be taken to view them without enhancing the susceptibility of the vehicle to visual detection. Vehicle placement and motion shall be randomized to preclude the observers from detecting patterns in the test sequence.

C.3 Hot Surfaces. Red hot exhaust systems constitute a source of visible radiation that can also betray a SUT at night unless the surfaces are shielded. Night observations must be made to determine the extent which these surfaces are shielded; hence, visual observations must be reliable. Vehicle "warm-up" times shall be of sufficient length to ensure that "steady-state" conditions are obtained for each observation. Testing should be done at low, mid-range and high rpm.

C.4 Exhaust Visibility. Exhaust visibility is a characteristic primarily associated with diesel-powered SUT(s); therefore, these tests need not be performed on SUT(s) with spark-ignition engines. Observations shall be made with the observers in the most advantageous positions to view the exhaust outlet opening (Aberdeen Proving Ground (APG) Report No. DPS-1204[13]).

C.5 Smoke. Exhaust smoke is a problem associated primarily with diesel engines. The amount and characteristic color and intensity of the smoke produced is determined by SUT operating conditions such as load, fuel type, temperature, humidity, and rack position.

C.6 Flame.

a. Exhaust flames, particularly torching, occur when a high concentration of unburned fuel in the exhaust gases is ignited by hot exhaust manifolds and pipes. This phenomenon is best observed after dark under varying load and speed conditions, particularly during acceleration and deceleration.

b. To best determine whether exhaust flames are detectable and the extent to which they affect the security of the SUT, photography is utilized. The exhaust flames furnish the illumination and the SUT is not lighted externally. Comparison photographs of different SUTs must be made under identical conditions.

APPENIX C. OTHER SECURITY DETECTION TYPE TESTS

C7. Ice Fog. Ice fog, a phenomenon associated with operation under conditions of extreme cold, is often visible at great distances, particularly in convoy operations. Ice fog should be observed qualitatively during the conduct of tests under arctic conditions. Visibility characteristics attributable to the design of the exhaust system should be particularly recorded. Thus, a SUT which disperses engine exhaust with cooling air may be less visible than one exhausting upward without turbulence.

C.8 Road Dust Visibility.

a. Road dust disturbances caused by poorly located exhaust pipes, engine cooling air exhausts or other vehicle peculiarities must also be taken into consideration. The visibility of the dust pattern raised by the SUT is evaluated by comparing it with dust from a comparable baseline SUT operating under the same conditions.

b. To compare the dust patterns, each SUT is operated separately over a selected section of a dusty cross-country course at various speeds and the dust pattern observed. Qualitative observations are to be made from appropriate vantage points and the heights of the dust clouds recorded with a digital video recorder or digital color camera for later analyses.

APPENDIX D. ME, MOL AND MCS DATA SHEETS

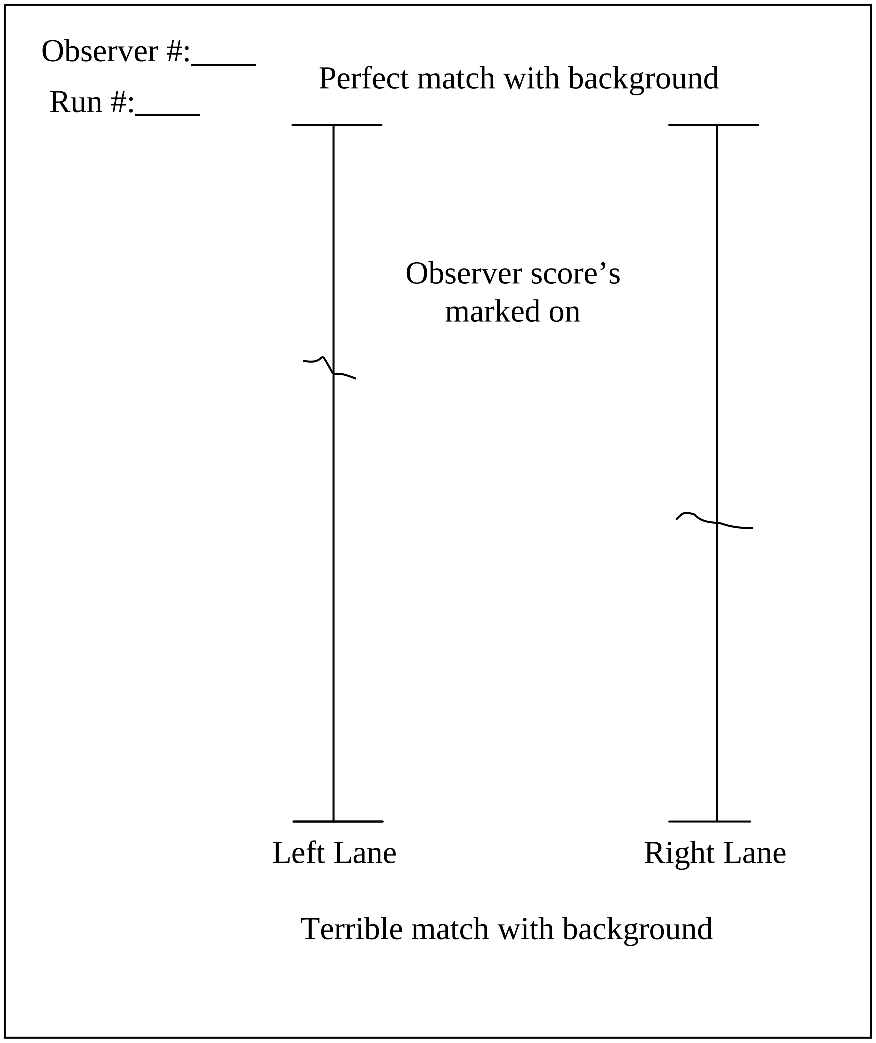

Figure D-1. ME paper score sheet hand marked.

APPENDIX D. ME, MOL AND MCS DATA SHEETS

Figure D-2. PPC configured for ME test.

Figure D-3. PPC configured for MOL or MCS test.

APPENDIX E. ABBREVIATIONS.

ANSI	American National Standards Institute
APG	Aberdeen Proving Ground
BII	Basic Issue Items
CIV	civilian
DRI	Detection, Recognition and Identification
DoD	Department of Defense
FOR	field of regard
FOV	field of view
IR	infrared
ITOP	International Test Operations Procedure
LOS	lines of sight
MCS	Method of Constant Stimuli
ME	Magnitude Estimation
MIL-STD	Military Standard
MOL	Method of Limits
MOS	Military Occupational Specialty
OVE	On-Vehicle Equipment
PD	Probability of Detection
PDA	Personal Data Assistant
PM	Program Manager
PPC	Personal Pocket Computer
RH	relative humidity
rpm	revolutions per minute
SI	International System of Units
SSG	Staff Sergeant
SUT	System Under Test
TMDE	Test Measurement Diagnostic Equipment
TOP	Test Operations Procedure
TVT	Titmus® Vision Tester
USMC	United States Marine Corps

.

APPENDIX F. REFERENCES

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